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prime motor sufficiently reliable was the steam-engine.

To get the strongest and the lightest was the problem.

It is true that carbonic acid had been liquefied some years before then, but no one knew how to harness it.

Having determined the probable force wanted, engine builders were found who agreed to make the engine light enough and of sufficient horse power, and the frame of the machine was set up at Hoboken, N. J. The fans were made for the lifting and driving, and the intermediate gear of bronze was cut. The body of the machine was complete.

At this stage it seemed that it only remained to get pressure enough upon the piston of the engine and maintain that pressure.

During the siege of Fort Wagner before Charleston we had used calcium lights, and had had great trouble to make the gas holders tight enough to prevent leak at high pressures. Mr. Mirriam, of Springfield, Mass., had succeeded in the field by a new method of floating the joints. Bennett and Risley, of Greenwich Street, New York, who undertook the engine, believed that they could make the joints of the boiler, the gaskets, the grummits and moving parts of the engine so as to work well under the required very high pressure of steam, by their new process, which seemed reasonable. Weeks, however, ran into months. They were unfortunate in their experiments, and the needed force of steam was not reached before the coming of Appomattox.

A description of the machine with a general and some detail drawings with tabulated data of the lifting capacity of the fans was filed with a rough model in the engineer department of the army at Washington, D. C., and a copy of the general plan was given to Mr. Prentice, whose office is now at 44 Broadway, New York City, and the Duke of Argyle was informed of what had in a general way been done by the army.

My conclusion was that at that time no existing machine would develop power enough to fly mechanically, without the use of gas-holders.

The use of liquid carbonic acid gas, CO₂,

has changed the situation. Valves have been made to work well at great speed under three or four times the highest pressure of steam applied to reciprocating engines, and about five years ago a report was so made to the chief of engineers of the army.

The elimination of the boiler, water and fuel and the substitution of stored energy in the shape of liquid CO₂, greatly reduces the weight of machinery, and the conclusion reached at the last analysis of this problem is that for army use a radius of action of about eight hundred miles is now attainable, after some experimentation, as the chief difficulty, the valves, have already been tested to a success with pressures as high as are necessary.

Nothing is known by the writer of the details of the machinery recently tried by the brothers Wright in North Carolina, except that obtained from imperfect newspaper accounts, but from what has been published it would seem that their machine is very much like, if not identical, with the army machine here described; but whether this is so or not, they are to be most heartily congratulated upon the measure of success that has crowned their efforts, and this kind thought extends to my friend of years gone by—Chanute—who is reported to have helped them.

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NOTES ON ANIMAL BEHAVIOR.

TO THE EDITOR OF SCIENCE: It has been suggested to me that it would be worth while to put on record two or three rather curious instances of animal behavior which have come to my notice during the past few weeks. The subject of these observations is a two-year-old black-and-tan terrier belonging to my sister. A few weeks ago as the family was at dinner one evening my mother said, 'What did the postman bring this afternoon?' 'Only a couple of advertising cards,' said my sister, 'which I threw in the waste-basket.' Nothing more was said on the subject, but a moment later the dog, who had been sitting on a chair in the same room, ran to the basket and, taking one of the very cards referred to in his mouth,

ran around the table and stood with it beside my mother, looking up into her face and wagging his tail. I fear that some of our popular writers on animals would at once attribute a rather remarkable reasoning power to this dog, saying that he thought my mother would like to see the card, and so selecting it from the others in the basket took it to her and expected to be rewarded for his thoughtfulness. But there is a much more reasonable explanation. He is still very playful, and as he jumped from the chair and ran about the room the card projecting above the edge of the basket caught his eye, and the play instinct prompted him to seize it. The fact that he did this just after my sister had spoken of the card was a mere coincidence. His running to my mother with the card is easily explained. Several months ago, while he was still a puppy, in fact, he frequently pulled papers from this same basket and was punished for doing so, until he entirely gave up the habit. As soon as he had taken the card from the basket, the memory of former punishments for similar acts doubtless recurred to him. Now my mother is intensely sympathetic, and whenever he is punished or likely to be punished he invariably runs to her, knowing that he will be petted and may even get a lump of sugar; if the recollection of punishment came to him, he would naturally follow his habit and run to her.

It was about a week after this that my sister sat in the same dining room later in the evening reading a book, while the dog, who is as restless as dogs of that variety usually are, was running about looking for something to play with. At last my sister said, without looking up from her book and in an ordinary tone: 'Teddy, if you go down cellar and bring up a stick of wood, I'll play with you.' The dog stood beside her as she spoke and immediately darted out into the kitchen, down the stairs into the cellar and soon reappeared beside my sister with a stick of wood. This was not a trick that he had been taught. He has several times during the past winter carried sticks of wood from the cellar to the kitchen, and at times has been praised with such words as: 'Nice dog to bring up wood

from the cellar.' But this carrying the wood has always been done voluntarily. Different members of the household when in the cellar have told him to carry up sticks, and he has never done so; sometimes a stick has been put in his mouth in the cellar, but after taking it as far as the stairs he would drop it and run up alone. He has been told a few times to go to the cellar and bring up a stick, but no attempt has been made to teach him to do so, and he has never done it except in the instance noted above. Since the evening in question the same remark has been made to him several times, and he has not responded to it in any way. The explanation would seem to be that he had learned to associate the words 'cellar' and 'stick' with the objects themselves and probably the word 'play' with the corresponding activity, for my sister plays with him a great deal and on such occasions frequently repeats the word 'play,' as 'Now let us play' or 'Come, play with your ball.' At the time in question the play instinct acted as a strong stimulus, probably a 'felt-need' from within, such as I have referred to in my text-book, and hence the special response. The whole act, then, involves no factors more complicated than memory and the association of names with objects, a faculty which dogs possess in considerable degree.

This same terrier, for example, associates the word 'ball' with the corresponding object with which he plays. If some one is in the pantry and you say to him, 'Go to the pantry and they will give you a piece of dog-biscuit,' he invariably goes for it, as he has doubtless learned to associate the words 'biscuit' and 'pantry' with the objects themselves. In the same way if you say to him, 'The grocer is coming into the kitchen to take orders; you must stay here in the dining room,' he invariably does so, although he is always very eager to see and jump upon any person who enters the house. The simple words, 'Grocer! stay here!' will have the same effect in keeping him out of the kitchen. He has likewise learned to associate the words, 'He is coming,' with the approach of any one to the house. I generally go home only on Sundays and at variable hours, and if the house is

quiet my mother sitting in the drawing room can say quite softly, 'I believe he is coming,' when the dog, two or three rooms distant and apparently asleep, will start up and run from window to window, looking up and down the street. He will do the same on any other day and for any individual, but with some variation in the rapidity of his response. I record these acts merely to show that while they might superficially appear to be the result of reasoning processes, they are doubtless only instances of memory and the association of spoken words with the objects or acts.

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SPECIAL ARTICLES.

THE INHERITANCE OF SONG IN PASSERINE BIRDS.

REMARKS ON THE DEVELOPMENT OF SONG IN THE
ROSE-BREASTED GROSBEAK, *ZAMELODIA LUDO-*
VICIANA (*LINNÆUS*), AND THE MEADOW-
LARK, *STURNELLA MAGNA* (*LINNÆUS*).

I AM tempted to elaborate at some length the life history of two broods of young birds that were raised in May and June, 1903, that definite data may be before the reader and student, as to exactly what has occurred for the past year with the individuals under observation.

On the 7th of June, 1903, I found a nest of rose-breasted grosbeaks in a swamp on the Millstone River, near Princeton. At the time of discovery the female was sitting, and presumably brooding new-laid eggs. She was not disturbed, but as I did not know when incubation had commenced, the locality was visited and observations were made at intervals of every other day, until on the 14th of the month I was assured that the young had been hatched. I was not then aware of the number of fledglings composing the brood. It seems worthy of record here that both parents took part in incubation, though the male only assumed such duty for brief periods, when the hen bird went away, probably for exercise and bathing, but not in quest of food. The male constantly fed the female and was solicitous in his care for her.

On the 14th of the month the young were hatched, and the parents shared the duties

of brooding as they had shared the period of incubation. On the 19th of the month, concluding that the young were old enough for the experiment in view, I secured the nest, in which were a brood of three fledglings, and at once had a water-color sketch made of the young in the nest, as a record of their absolute condition, so far as feathering and appearance were concerned. While not able to discriminate with certainty the differentiation in sex, I was reasonably sure from the first that the brood contained two young male birds and one female.

On the 20th another accurate water-color sketch was made to record how these birds had grown and developed, and on the 21st a sketch of one of the birds, a male, for by this time the sexes were easily distinguishable, records his appearance from both a front and a back view.

These birds were carefully hand reared in the nest, which they left on the twenty-first inst., when about seven days old. Grosbeaks of this kind are very precocious, and being admirable climbers, they clamber about long before they are able to fly, on the limbs and tangle of vines which generally surround the nest.

It seems improbable that during the first four days of their lives these birds acquired much appreciation of the song of the male parent, though he was constantly singing close at hand.

The three young birds were successfully reared, and are alive at the present writing. The brood consisted, as I had anticipated from the first, of two males and one female. The birds were kept together for the first six or seven months of their lives, in a large cage, and as I had no other male grosbeak in my laboratory, it was, of course, quite impossible that they should have learned anything of the method of song of their ancestors, except such impression as may have been gathered during the first four days of their lives. All of them went through the regular moult, and assumed by September the characteristic dress of rose-breasted grosbeaks at that season of the year. In October the two young males both developed a change in appearance which progressed slowly